DOCUMENT RESUME

ED 044 028   EM 008 435

AUTHOR   Bell, Norman T.; Moon, Robert D.
TITLE   Teacher Controlled Computer Assisted Instruction.
INSTITUTION   Michigan State Univ., East Lansing.
PUB DATE   [69]
NOTE   27p.

EDRS PRICE   EDRS Price MF-$0.25 HC-$1.45
DESCRIPTORS   Business Education, *Computer Assisted Instruction,
                *Computer Oriented Programs, Computer Programs,
                Computer Science Education, *Estimated Costs,
                Information Retrieval, Language Arts, Mathematics
                Instruction, Science Instruction, Statistics
IDENTIFIERS   Basic Indexing and Retrieval System, BIRS

ABSTRACT
          In this time of high cost, it is important not to
focus on tutorial computer-assisted instruction (CAI) as the only way
to use a computer effectively in instruction. Teacher controlled
CAI--classroom use of CAI, augmented by a television
display--provides one alternative. Non-tutorial classroom
demonstrations can be arranged in business education, in science, and
in statistics. Simple games with a computer can be played by a
Mathematics class and, also, by a Language Arts class. Another
alternative, not usually considered as being part of CAI, is class
use of information retrieval. High cost may even be justified when
computers are used to teach about computers. A computer program for
determining whether to rent or to buy a computer system is given. (MF)

TEACHER CONTROLLED COMPUTER ASSISTED INSTRUCTION

Norman T. Bell

Robert D. Moon

Michigan State University

INTRODUCTION

It would be unwise to consider any aspect of computer assisted instruction as being a part of normal classroom operation without simultaneously considering cost. Financial feasibility of computer assisted instruction is a subject which has been used both to support and discourage its use. Most often when the financial feasibility is used in support of CAI, it is spoken of in terms of future applications. Because of the costs, present CAI systems have been justified in terms of special application, experimentation, and are cited as specific examples of methods of helping students who are not learning effectively under normal procedures.

Not until experimentation and plans for the future are supplimented by tangible evidence of financial feasibility will CAI become much more than an experimental tool or novelty for the affluent or government-supported school systems. This paper will examine ways of using CAI in the classroom and attempt to determine which of the ways may now be feasible in terms of costs.

A CAI COMPUTER SYSTEM

In considering a CAI computer system there are two major areas which must be examined. These are computer hardware and instructionally oriented software. The primary consideration of software in this paper will be in connection with intended uses. With respect to procuring the necessary computer hardware, there

are three options available to a potential user. These are (1) rental of
time-sharing system, accessed by computer terminals, (2) rental of the total
system, and (3) purchase of the total system. These options will be examined
individually in terms of approximate cost per student hour.

Option 1: Rental of time

A survey of the costs associated with the use of nineteen commercial
systems is presented in Figure 1. Raw data for this figure were drawn from

Figure 1:   A Cost Survey of Time-Sharing Commericial Firms With a CAI
            Language Capability.

19 Commercial Firms
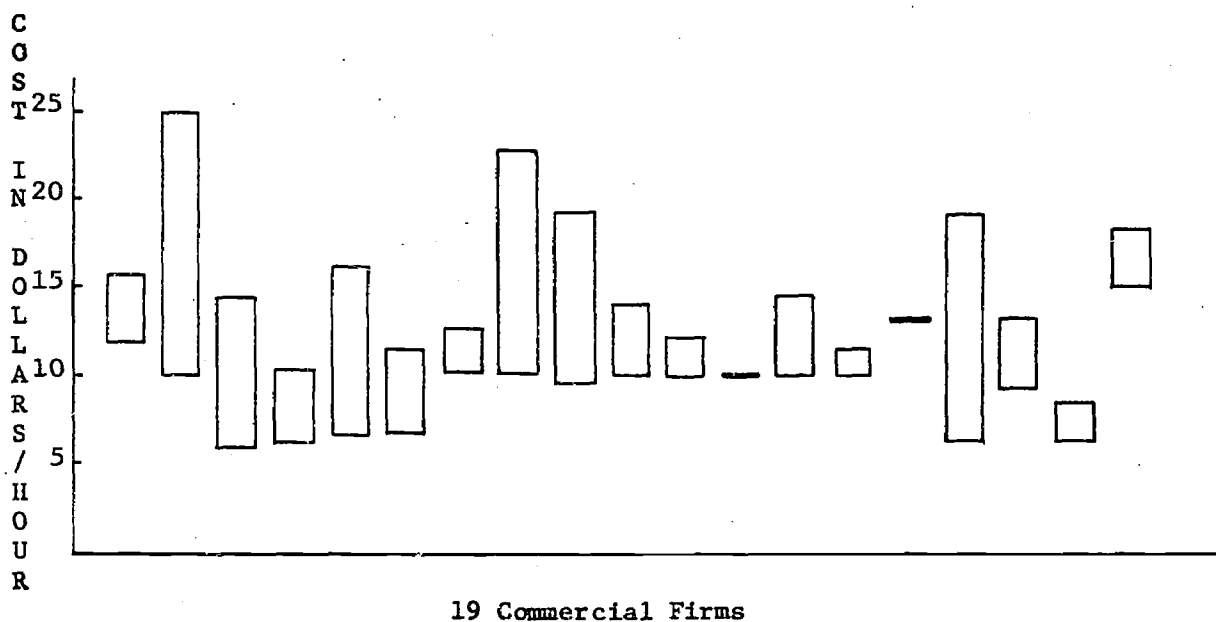
computer research corporation (1968). From this survey it appears that a reason-
able cost range of time-shared equipment is 10 to 15 dollars per hour. The range
of cost for each system was determined by combining costs of connect time and
compute time. The range was established with the low estimate indicating cost

of connect time and the high estimate indicating cost of one half minute of compute time added to each hour of connect time. In some cases the range includes variable terminal costs. It must be noted that only about one quarter of the systems studied has an instructionally oriented language, other than BASIC, available to its users. This tends to suggest that these systems have been instituted mainly for the commercially-oriented users.

Options 2 and 3. Rent or buy complete computer system

Following is a partial list of questions which a potential user must consider in deciding whether to rent or buy the computer system for CAI.

1. What increase in staff is needed to operate the computer system?

2. What costs are incurred for these additional staff?

3. Will the acquisition of such a system allow a reduction in the teaching staff?

4. If such a reduction is possible, what savings will be realized?

5. What is the maximum number of students to be serviced individually at one time?

6. Will the computer system be used for activities other than instruction?

7. Among the systems being considered, what instructional programming languages are available?

8. Do any of the systems have available instructional programs which meet the needs of the students in the school system?

9. If the decision is to be the computer system, what type of depreciation schedule is to be used.

Because of the number of variables which must be handled simultaneously, many of these questions have been incorporated in a conversational computer program

designed to assist potential users in their investigations of the cost of

owning or renting a CAI system. Figures 2 and 3 represent sample output of

this program. It must be noted that while this program has been designed

to assist in determining cost per student hour of operation, there are a

number of other factors which must be considered in the acquisition of such

a system.

COST

CAI SYSTEM COST ANALYSIS

ARE YOU GOING TO RENT OR BUY THE CAI SYSTEM?
BUY
HOW MANY TERMINALS DO YOU WISH TO HAVE?
      (WHERE POSSIBLE ANSWER WITH NUMERALS)
☐:
      15 30 45 60
HOW MANY ADDITIONAL STAFF WILL YOU NEED FOR THIS SYSTEM?
☐:
      7
WHAT IS THE AVERAGE SALARY OF ADDITIONAL STAFF?
☐:
      9500
HOW MANY TEACHERS WILL BE REPLACED WITH THIS CAI SYSTEM?
☐:
      0
WHAT IS THE AVERAGE NUMBER OF HRS/WK THAT A TERMINAL IS USED?
☐:
      30
WHAT IS THE COST OF THE COMPUTER?
☐:
      756540
WHAT IS THE COST OF ONE TERMINAL?
☐:
      6500
WHAT IS THE MONTHLY VALUE OF THE SPACE OCCUPIED BY COMPUTER?
☐:
      1000
WHAT IS THE NUMBER OF MONTHS USED FOR THE
DEPRECIATION SCHEDULE FOR THE EQUIPMENT?
☐:
      60
DO YOU PLAN TO USE THIS COMPUTER SYSTEM FOR ADMINISTRATIVE
DATA PROCESSING?
YES
WHAT PERCENTAGE OF THE TOTAL EXPENDITURE FOR THIS SYSTEM
WILL YOU ALLOCATE TOWARD ADMINISTRATIVE DATA PROCESSING?
☐:
      35
THE COST PER STUDENT HOUR IS 6.57383   3.55701   2.5514   2.04859   DOLLARS

Figure 2

COST

CAI SYSTEM COST ANALYSIS

ARE YOU GOING TO RENT OR BUY THE CAI SYSTEM?
RENT
HOW MANY TERMINALS DO YOU WISH TO HAVE?
    (WHERE POSSIBLE ANSWER WITH NUMERALS)
□:
     15 30 45 60
HOW MANY ADDITIONAL STAFF WILL YOU NEED FOR THIS SYSTEM?
□:
     7
WHAT IS THE AVERAGE SALARY OF ADDITIONAL STAFF?
□:
     9500
HOW MANY TEACHERS WILL BE REPLACED WITH THIS CAI SYSTEM?
□:
     0
WHAT IS THE AVERAGE NUMBER OF HRS/WK THAT A TERMINAL IS USED?
□:
     30
 WHAT IS THE MONTHLY RENTAL OF THE COMPUTER?
□:
     16510
 WHAT IS THE MONTHLY RENTAL OF ONE TERMINAL?
□:
     200
WHAT IS THE MONTHLY VALUE OF THE SPACE OCCUPIED BY COMPUTER?
□:
     1000
DO YOU PLAN TO USE THIS COMPUTER SYSTEM FOR ADMINISTRATIVE
DATA PROCESSING?
YES
WHAT PERCENTAGE OF THE TOTAL EXPENDITURE FOR THIS SYSTEM
WILL YOU ALLOCATE TOWARD ADMINISTRATIVE DATA PROCESSING?
□:
     35
THE COST PER STUDENT HOUR IS 8.32768 4.66247 3.44073 2.82986   DOLLARS

Figure 3

Figure 4 shows the cost for computer configuration which can support CAI. The cost of one dollar per student hour is made on claims of a 10,000,000 dollar plus system yet to be implemented. Excluding this value a reasonable range for costs appears to be 3 to 7 dollars. Other studies, Kopstein and Seidel (1967), Silbermand and Filep (1968), and Bitzer and Slottow (1966), for example, imply that for the present CAI costs are higher than traditional instruction, but are optimistic concerning future costs.

Figure 4. Estimated Cost Per Student Hour For Various CAI Systems

Purchase Cost of System	Number of Terminals							
	1	5	10	15	30	45	60	1000
*120,000	4.50	2.50	1.60	1.25				
650,000					3.75			
850,000				6.50	3.75	2.80	2.30	
900,000				7.00	4.00	3.00	2.50	
900,000						3.50		
**10,000,000								1.00

*The figures for more than 1 terminal have been demonstrated only with Fortran as a language.

**This estimate is on projection of a system which has been released, but has not been demonstrated in a CAI mode.

Financial Conclusions

In most school systems even the cost of one dollar per student hour would limit extensive use of a computer in a tutorial mode. If a class of 30 students were to use a computer only 20 minutes per day per student they would use about

$200 of time per month at the one dollar figure. At $4 per student hour, which appears more realistic on presently available systems, the cost would be $800 per month. At commercial rates of $10 per student hour, the cost would be $2000 per month. Even having the students use the system 20 minutes per day could at most enrich instruction and would likely not reduce teacher cost, which means these are additional costs. The above figure also assume there is little or no cost for instructional programming which is rarely the case.

Thus an analysis of present costs raises the question "Can or should the computer be a part of a normal instructional program?" The answer to this question might in part be suggested by a second question, "Are educators focusing too strongly on tutorial applications of the computer." The remainder of this paper will examine several non-tutorial uses of the computer in instruction. The examples are drawn from Michigan State and local school systems.

Computers for What?

A crucial question needs to be considered--"is it more important for people to be learning from computers or about computers?" A review of CAI applications in elementary and secondary schools would indicate that the majority of efforts have been tutorial in nature. However, the growing use of computer in our culture indicates it is extremely important to learn about computers. Such a view has amply document in the Report of the President's Science Advisory Committee (1967). The ideal answer then may be to learn about computer while learning from the computer. It appears some of the most financially feasible instructional uses of the computer may be those which also aid in an understanding of the computer.

Criteria for Instructional Decisions Concerning Computers

The following criteria may aid the potential user in decisions related to instructional applications of the computer:

A. The Computer as the Medium of Instruction

   1. The computer performs tasks related to the instructional objectives which cannot be done as effectively in any other manner.

   2. The computer performs tasks related to the instructional objectives which cannot be duplicated at less cost and with reasonable effort by some other method.

   3. The use of the computer provides better motiviation for meeting the instructional objectives than any other readily available method.

B. The Computer as the Object of Instruction

   The students learn:

   1. about how a computer functions,

   2. about the type of functions a computer is best capable of doing,

   3. to communicate with a computer via some level of programing or interactive language.

C. Availability of Software

   1. Programs exist to do the desired instructional task.

   2. Teachers can readily program the system to do the desired task.

   3. There exists computer aided programing which will build a program to perform the desired tasks.

D. Instructional Control and Student-to-Terminal Ratio

   1. Teacher controls a demonstration terminal in the classroom.

   2. A small group of students works simultaneously at one terminal.

   3. There is one student per terminal at a given time.

These criteria will now be illustrated and applied in the following examples of instructional programing.

Examples of CAI Programs Designed for Non-Tutorial Use

The six sets of examples, chosen from various subject matter areas, represent some of the possible types of non-tutorial CAI. Each of these examples will be presented with a brief discussion of the program and its implications in instruction. Where necessary suggestions for implementation will be offered.

Business Education

Figures 5.1 through 5.3 illustrate several programs relating to time financing. These programs have been constructed so they can be used by the teacher for classroom demonstrations. For such a demonstration, the teacher solicits from the student values for the input variables of amount of loan, rate of interest, and length of loan. It should be noted that multiple values may be used for any single variable, thus allowing for a large number of students to select a value for a variable. It should also be noted that an immediate comparison of total payments may be made simp. by instructing the computer to used stored data in the desired manner. Through this operation the student may be made aware of the computer operating as a computer, for example by requesting the computer to display the program so as to determine where the data are stored.

For optimum learning with the one-terminal-per-class model, it is desirable that the whole class be able to see the computer output as it is printed. Various means have been provided for group displays of computer output. Our experience has indicated that a closed-circuit television system, costing less than $600, has proved to be most effective. With such a system additional monitors are used as the class size increases.

```
        PAY
WHAT IS THE AMOUNT OF THE LOAN?
□:
        5000
WHAT IS THE INTEREST RATE PER YEAR?
□:  -
        10
HOW MANY MONTHS IS THE LOAN TO RUN?
□:
        12 24 36
YOUR MONTHLY PAYMENT = 439.57  230.72   161.33
REMEMBER THAT TAXES AND INSURANCE ARE
NOT INCLUDED IN THIS PAYMENT.


        ∇PAY[□]∇
     ∇ PAY
[1]     'WHAT IS THE AMOUNT OF THE LOAN?'
[2]     A←□
[3]     'WHAT IS THE INTEREST RATE PER YEAR?'
[4]     I←(□÷12)÷100
[5]     'HOW MANY MONTHS IS THE LOAN TO RUN?'
[6]     M←□
[7]     P←(A×I×(1+I)*M)÷(((1+I)*M)-1)
[8]     'YOUR MONTHLY PAYMENT = ';(⌊(0.5+P×100))÷100
[9]     'REMEMBER THAT TAXES AND INSURANCE ARE '
[10]    'NOT INCLUDED IN THIS PAYMENT.'
     ∇

        M
12   24   36
        P
439.574   230.722   161.334
        M×P
5274.89   5537.33   5808.03

        PAY
WHAT IS THE AMOUNT OF THE LOAN?
□:
        15000
WHAT IS THE INTEREST RATE PER YEAR?
□:
        6.5
HOW MANY MONTHS IS THE LOAN TO RUN?
□:
        120 240 360
YOUR MONTHLY PAYMENT = 170.32   111.84    94.81
REMEMBER THAT TAXES AND INSURANCE ARE
NOT INCLUDED IN THIS PAYMENT.
        M×P
20438.7   26840.7   34131.7
```

Figure 5.1

```
      LOAN
                   LOAN PROGRAM
                   ====  =======

WHAT IS THE AMOUNT OF THE LOAN?
□:
       1000
WHAT IS THE INTEREST RATE PER YEAR?
□:
       7
HOW MANY MONTHS IS THE LOAN TO RUN?
□:
       12
AMOUNT = 1000
INTEREST PER YEAR = 0.07
NUMBER OF MONTHS = 12

  PAYMENT        INTEREST       BALANCE
  ------------------------------------


   86.53          5.83          919.31
   86.53          5.36          838.14
   86.53          4.89          756.51
   86.53          4.41          674.39
   86.53          3.93          591.8
   86.53          3.45          508.73
   86.53          2.97          425.17
   86.53          2.48          341.12
   86.53          1.99          256.59
   86.53          1.5           171.56
   86.53          1             86.03
   86.53          0.5           0.01


TOTAL PAYMEMTS = 1038.31
TOTAL INTEREST =38.3212
```

Figure 5.2

```
      MORT
WHAT IS THE INTEREST PER YEAR? TYPE NUMBER ONLY.
□:
  6.5
WHAT IS THE ORIGINAL MORTAGE ?
□:
  15000
WHAT ARE THE MONTHLY PAYMENTS ?
□:
  210.30
HOW MANY MONTHS ARE TO BE DISPLAYED ?
□:
  20
WHAT IS THE MONTHLY DEDUCTION FOR TAXES AND INSURANCE ?
□:
  40
DISPLAY EVERY ___MONTH. E.G. FOR EVERY THIRD MONTH TYPE 3
□:
  12

MONTH [12 ] BALANCE OF MORTAGE = 13899    TOTAL INTEREST = 942.583   EQUITY = 1101.02
MONTH [24 ] BALANCE OF MORTAGE = 12724.2  TOTAL INTEREST = 1811.43   EQUITY = 2275.77
MONTH [36 ] BALANCE OF MORTAGE = 11470.8  TOTAL INTEREST = 2601.6    EQUITY = 3529.2
MONTH [48 ] BALANCE OF MORTAGE = 10133.4  TOTAL INTEREST = 3307.82   EQUITY = 4866.58
MONTH [60 ] BALANCE OF MORTAGE = 8706.48  TOTAL INTEREST = 3924.48   EQUITY = 6293.52
MONTH [72 ] BALANCE OF MORTAGE = 7183.97  TOTAL INTEREST = 4445.58   EQUITY = 7816.02
MONTH [84 ] BALANCE OF MORTAGE = 5559.5   TOTAL INTEREST = 4864.7    EQUITY = 9440.49
MONTH [96 ] BALANCE OF MORTAGE = 3826.24  TOTAL INTEREST = 5175.04   EQUITY = 11173.8
MONTH [108] BALANCE OF MORTAGE = 1976.89  TOTAL INTEREST = 5369.29   EQUITY = 13023.1
MONTH [120] BALANCE OF MORTAGE = 3.69394  TOTAL INTEREST = 5439.69   EQUITY = 14996.3
```

Figure 5.3

Science

Figure 6 shows a typical application from the area of science. Instructionally, such a program would be utilized by the teacher in a mode similar to that of the example from business education. It may be desirable for the teacher, working with the class, to use the data generated from the class input to derive a mathematical model. The savings in time compared to that required by laboratory replications is obvious. There are numerous other such applications possible in the area of science.

Statistics

Figures 7.1 through 7.5 illustrate some of the many interactive statistical programs applicable for instructional use. In a course in experimental design, data for each student or group of students were randomly selected from given distributions and stored in the computer. The students were given a description of the hypothetical conditions of how the data were collected. The students then could make use of any of a number of statistical tests for the purpose of analyzing data. For these types of exercises students operated both singly at the computer and in small groups. Figure 7.1 illustrates the display of two stored distributions and an analysis of these using linear regression. Figure 7.2 illustrates a program designed to display ordered frequency distributions. In this example 100 randomly generated scores ranging from 1 to 10 were used. Finally, a conversational one-way analysis of variance is depicted in Figure 7.3.

Figures 7.4 and 7.5 show the results of an instructional demonstration related to sampling. As indicated at the top of Figure 7.4, A is a

```
        GAS
WHAT UNITS OF PRESSURE DO YOU WISH TO USE?
MM
WHAT UNITS OF VOLUME DO YOU WISH TO USE?
L.
WHAT IS THE PRESSURE?
□:
        800
WHAT IS THE VOLUME?
□:
        4
WHAT IS THE TEMPERTURE IN ° KELVIN?
□:
        300
800  MM          4  L.            300  ° KELVIN


        CTVE   1 3 5 8 16
 3200  MM           1  L.             300  ° KELVIN
 1066.67  MM            3  L.             300  ° KELVIN
 640   MM           5  L.         300  ° KELVIN
 400   MM           8  L.         300  ° KELVIN
 200   MM           16  L.            300  ° KELVIN


        CPVE  100 200 400 800 1600 3200
 200   MM           100  L.            1875  ° KELVIN
 200   MM           200  L.            3750  ° KELVIN
 200   MM           400  L.            7500  ° KELVIN
 200   MM           800  L.            15000  ° KELVIN
 200   MM           1600  L.           30000  ° KELVIN
 200   MM           3200  L.           60000  ° KELVIN


        CPTE  100 200 300 400 500 600 700 800
 200   MM           5.33333  L.            100  ° KELVIN
 200   MM           10.6667  L.            200  ° KELVIN
 200   MM           16  L.          300  ° KELVIN
 200   MM           21.3333  L.            400  ° KELVIN
 200   MM           26.6667  L.            500  ° KELVIN
 200   MM           32  L.          600  ° KELVIN
 200   MM           37.3333  L.            700  ° KELVIN
 200   MM           42.6667  L.            800  ° KELVIN


        CTPE  400 800 1600 3200
 400   MM           21.3333  L.            800  ° KELVIN
 800   MM           10.6667  L.            800  ° KELVIN
 1600  MM            5.33333  L.           800  ° KELVIN
 3200  MM            2.66667  L.           800  ° KELVIN
```

Figure 6

```
        IQ
 138  138  133  131  128  128  126  12S  125  124  124
      124  123  123  123  123  120  119  118  118
      117  117  116  116  116  115  115  115  114
      113  113  113  112  112  112  111  111  110
      110  109  109  108  108  108  108  106  105
      105  105  104  103  103  102  101  101  101
      100  100  100  100  99  99  98  97  94  94  93
       92  89  88  79


        MAT
 68  64  56  57  50  57  43  47  28  57  42  64  49
      61  47  57  46  48  59  57  37  17  41  50  36
      46  60  34  60  15  27  50  56  50  49  55  43
      61  23  38  47  30  36  31  39  28  57  41  54
      49  41  28  42  31  51  54  45  23  34  25  26
      37  38  45  26  28  30  37  27  28  15
```

```
        IQ REG MAT
WHAT IS THE NAME OF YOUR LEFT VARIABLE?
IQ
WHAT IS THE NAME OF YOUR RIGHT VARIABLE?
MAT
TO PREDICT MAT FROM IQ USE THE EQUATION (   PREDICTED MAT=
      ¯27.01246737+0.6278097466IQ)
 TO PREDICT IQ FROM MAT USE THE EQUATION (   PREDICTED IQ=
      88.01785291+0.5378905031MAT )
R=0.5811135005
 T EQUALS 5.931380776  THERE ARE 69 DEGREES OF FREEDOM
```

Figure 7.1

```
        ARM ?100p10
```

SCORES	FR.	CUM. FR.	CUM. PCT.	Z-SCORES
10	10	100	100	1.627
9	11	90	90	1.277
8	5	79	79	0.926
7	11	74	74	0.575
6	8	63	63	0.224
5	15	55	55	¯0.126
4	7	40	40	¯0.477
3	10	33	33	¯0.828
2	16	23	23	¯1.178
1	7	7	7	¯1.529

Figure 7.2

```
        T1WAY
HOW MANY GROUPS DO YOU HAVE ?
☐:
        4
ENTER YOUR GROUPS ONE AT A TIME.
HIT THE RETURN KEY AFTER ENTERING EACH GROUP.
GROUR 1
☐:
        34 56 43 45 56 45 34 32 34 45 65 67 45 34 23
GROUR 2
☐:
        34 45 34 32 11 12 21 13 14 16 32 12 17 15
GROUR 3
☐:
        12 32 12 14 16 31 11 13 14 21 16 13 21 22 32
GROUR 4
☐:
        89 87 89 88 67 76 65 67 45 78 65 34 77 87 67 87
```

$SSB=29007.66667$ $SSW=8557.066667$ $SST=37564.73333$
$DFB=3$ $DFW=56$ $DFT=59$
$MSB=9669.222222$ $MSW=152.8047619$
$F=63.27827812$

CELL MEANS
43.86666667   22   18.66666667   73

Figure 7.3

A																				
2	2	3	4	5	6	5	4	3	4	4	5	6	7	8	7	8	9	3	2	1

ARM A

SCORES	FR.	CUM. FR.	CUM. PCT.	Z-SCORES
9	1	21	100	1.979
8	2	20	95.24	1.522
7	2	18	85.71	1.066
6	2	16	76.19	0.609
5	3	14	66.67	0.152
4	4	11	52.38	‾0.304
3	3	7	33.33	‾0.761
2	3	4	19.05	‾1.218
1	1	1	4.76	‾1.675

ARM (105 RG A)

SCORES	FR.	CUM. FR.	CUM. PCT.	Z-SCORES
9	4	105	100	2.03
8	11	101	96.19	1.569
7	10	90	85.71	1.107
6	10	80	76.19	0.646
5	10	70	66.67	0.185
4	21	60	57.14	‾0.277
3	22	39	37.14	‾0.738
2	12	17	16.19	‾1.2
1	5	5	4.76	‾1.661

MEAN A
4.66667
MEAN AV
4.6
STDEV A
2.18944
STDEV AV
2.16729

Figure 7.4

```
    A
9  8  8  7  7  6  6  5  5  5  4  4  4  4  3  3  3  2  2  2  1
```

```
    100 SAM 4
WHAT DISTRIBUTION DO YOU WISH TO USE?
□:
    A
DO YOU WISH TO SEE THE DISTRIBUTION OF SAMPLE MEANS?
NO
THE MEAN OF THE SAMPLE MEANS = 4.7525
THE STANDARD DEVIATION OF THE SAMPLE MEANS = 1.06741


    100 SAM 9
WHAT DISTRIBUTION DO YOU WISH TO USE?
□:
    A
DO YOU WISH TO SEE THE DISTRIBUTION OF SAMPLE MEANS?
NO
THE MEAN OF THE SAMPLE MEANS = 4.56
THE STANDARD DEVIATION OF THE SAMPLE MEANS = 0.704819


    100 SAM 16
WHAT DISTRIBUTION DO YOU WISH TO USE?
□:
    A
DO YOU WISH TO SEE THE DISTRIBUTION OF SAMPLE MEANS?
NO
THE MEAN OF THE SAMPLE MEANS = 4.62375
THE STANDARD DEVIATION OF THE SAMPLE MEANS = 0.465948


    MEAN A
4.66667


    (STDEV A)÷√4
2.18944   1.09472   0.729814   0.54736
```

Figure 7.5

distribution of scores. For sampling purposes a program has been written

which treats A as an infinite population with scores distributed in the

same proportion as the A indicated at the top of the figure. The lower

half of Figure 7.4 illustrates a sample of 105 scores randomly drawn from

the population A. Next the mean of the population A is shown followed by

the mean of the sample (N=105). Similarly the two standard deviations are

displayed.

In Figure 7.5 this same population is used as the basis for the examination

of distributions for 100 repeated samples of sizes 4, 9, and 16. Students

are able then to compare empirically-derived standard deviations of sample

means with theoretical values and draw conclusions about existing relation-

ships.

Mathematics

Figures 8.1 and 8.2 demonstrate a simple game which can be played

with the computer. The game has been used to illustrate mathematical

concepts relating to remainders upon devision by a given number. The game

may be played in a class with teams of students attempting to derive the

algorithm which will enable them to beat the computer. As was indicated

in the discussion of instructional uses of the computer in the area of

science, there are numerous other applications in mathematics.

Language Arts

The programs shown in Figures 9.1 and 9.2 illustrate a simple word

game used for the purpose of developing vocabulary. Because of the nature

of this game, it is evident that to change the game, the words would have

to be repeatedly replaced. To rewrite the program for each new set of words

```
        NIM
HOW MANY STICKS DO YOU WISH TO PLAY WITH? CHOOSE A NUMBER BETWEEN 10 AND A 100.
□:
   15
WHAT IS THE MAXIMUN NUMBER OF STICKS YOU CAN TAKE IN ONE MOVE? CHOOSE LESS THAN 6
□:
   4

DO YOU WANT TO MOVE FIRST OR LAST?
LAST
THE COMPUTER TAKES 4    STICKS
THERE ARE 11   STICKS
| | | | | | | | | | |
   YOUR MOVE HOW MANY DO YOU WANT?
□:
   3
THE COMPUTER TAKES 2    STICKS
THERE ARE 6    STICKS
| | | | | |
   YOUR MOVE HOW MANY DO YOU WANT?
□:
   4
THE COMPUTER TAKES 1
SORRY! THE COMPUTER WINS.
```

Figure 8.1

```
        NIM
HOW MANY STICKS DO YOU WISH TO PLAY WITH? CHOOSE A NUMBER BETWEEN 10 AND A 100.
□: 61

WHAT IS THE MAXIMUN NUMBER OF STICKS YOU CAN TAKE IN ONE MOVE? CHOOSE LESS THAN 21
□: 9

DO YOU WANT TO MOVE FIRST OR LAST?
LAST
THE COMPUTER TAKES 4    STICKS
THERE ARE 57    STICKS
||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 6

THE COMPUTER TAKES 7    STICKS
THERE ARE 44    STICKS
||||||||||||||||||||||||||||||||||||||||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 3

THE COMPUTER TAKES 6    STICKS
THERE ARE 35    STICKS
|||||||||||||||||||||||||||||||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 4

THE COMPUTER TAKES 9    STICKS
THERE ARE 22    STICKS
||||||||||||||||||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 1

THE COMPUTER TAKES 8    STICKS
THERE ARE 13    STICKS
|||||||||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 2

THE COMPUTER TAKES 5    STICKS
THERE ARE 6    STICKS
||||||
    YOUR MOVE HOW MANY DO YOU WANT?
□: 5

YOU WIN
```

Figure 8.2

```
            WDGAME
DO YOU NEED INSTRUCTIONS FOR THIS GAME?
YES
THIS INSTRUCTIONAL SEQUENCE DEMONSTRATES A VARIATION OF A
FAMILIAR WORD GAME.   THE RULES ARE:   CHANGE THE GIVEN WORD
ONE LETTER AT A TIME TO MAKE THE WORD INDICATED.  YOU MAY
ADD, TAKE AWAY, OR CHANGE A LETTER TO ANOTHER LETTER.


THE GAME STARTS WITH THE WORD ICE
THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF GRAIN
GUESS THE WORD

RAIN
HINT:   THE WORD RHYMES WITH VICE
TRY AGAIN
RICE


THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF CONTEST
GUESS THE WORD
RACE


THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF FRILL
GUESS THE WORD
LACE


THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF TARDY
GUESS THE WORD
LATE


THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF TARDIER
GUESS THE WORD
LATER


THE NEXT WORD IS SIMULAR TO OR AN EXAMPLE OF RAIN
GUESS THE WORD
WATER


GREAT!   YOU CHANGED ICE TO WATER WITH THE ADDITION OF A MINIMUM OF CALORIES.
```

Figure 9.1

```
        LOADG
HOW MANY QUESTIONS DO YOU HAVE ?
□:
        6
WHAT WORD STARTS THE GAME ?
ICE
WHAT IS THE WORD FOR QUESTION 1    ?
RICE
WHAT IS THE SIMULAR WORD FOR QUESTION 1.    ?
GRAIN
WHAT WORD IS TO BE A HINT FOR QUESTION 1    ?
VICE
WHAT IS THE WORD FOR QUESTION 2    ?
RACE
WHAT IS THE SIMULAR WORD FOR QUESTION 2    ?
CONTEST
WHAT WORD IS TO BE A HINT FOR QUESTION 2    ?
PACE
WHAT IS THE WORD FOR QUESTION 3    ?
LACE
WHAT IS THE SIMULAR WORD FOR QUESTION 3    ?
FRILL
WHAT WORD IS TO BE A HINT FOR QUESTION 3    ?
FACE
WHAT IS THE WORD FOR QUESTION 4    ?
LATE
WHAT IS THE SIMULAR WORD FOR QUESTION 4    ?
TARDY
WHAT WORD IS TO BE A HINT FOR QUESTION 4    ?
FATE
WHAT IS THE WORD FOR QUESTION 5    ?
LATER
WHAT IS THE SIMULAR WORD FOR QUESTION 5    ?
TARDIER
WHAT WORD IS TO BE A HINT FOR QUESTION 5    ?
WAITER
WHAT IS THE WORD FOR QUESTION 6    ?
WATER
WHAT IS THE SIMULAR WORD FOR QUESTION 6    ?
RAIN
WHAT WORD IS TO BE A HINT FOR QUESTION 6    ?
DAUGHTER
WHAT IS YOUR CLOSING STATEMENT ?
GREAT!   YOU CHANGED IN
```

                                    \'
                   CE TO WATER WIH

                                   v
                   TH THE ADDITION OF A MINIMUM OF CALORI

Figure 9.2

would involve more effort than is justifiable. For this reason, another
conversational program has been designed to enable the teacher to input new
sets of words. The sample output (Figure 9.2) shows that even a teacher
with no spacial programing abilities can input the new words. In fact,
this conversational program may also be used by students to build new
games for other students to play. Thus students gain both by playing the
game and by building games for other students to play.

Information Retrieval

There is a definited need to expand our concept of how computers may
assist in instruction. One example normally not considered as being part
of CAI is the storing, selecting and organizing of information. Students
and instructors at Michigan State University have been using BIRS (Basic
Indexing and Retrieval System), Vinsonhaler (1968), to search and retrieve
documents from two large files. The first of these files contains over
6000 abstracts in the area of computer applications in education. The
second contains about 2500 abstracts concerned with verbal learning and
concept learning, (Byers, 1968). With these computer searches providing
otherwise unobtainable materials for students, there is obvious assistance
in instruction. Also with computer searching the student learns more about
the use of computers at the same time he is obtaining the information
relevant to his studies.

Conclusion

There are many ways to use effectively a computer in instruction. While
tutorial uses represent one area of use, it is important not to focus on this
mode as the only use. The present costs of tutorial CAI appear to make it

inappropriate for most elementary and secondary schools. However, it is well to note that there are some high cost small size classes in universities and secondary schools where tutorial CAI may prove to be less expensive than traditional methods of instruction.

The cost per student hour of CAI may be reduced if there are many students operating from one terminal. The classroom use of CAI, augmented with television, appears to be one very effective method of accomplishing this many-for-one relationship. Using the computer in this manner there are many areas of instruction which can be presented more effectively and less expensively than the tutorial or other traditional methods.

The expanding use of computers in our society makes knowledge of computers increasingly important. Because of this, instruction from computers is best justified when it also teaches about the computer. Learning about computers and how to use them may justify the use of CAI even in situations where there are less expensive way to provide instruction.

Hence, this exploration in the area of teacher-controlled CAI may provide a means of bridging the gap during this time of high costs, and in so doing also may provide the experimental situation needed for the development and testing of materials which will be increasingly in demand in the event of successful cost reduction in the hardware area.

REFERENCES

BITZER, DONALD L.; SLOTTOW, H.G. "The Plasma Display Panel--A Digitally
    Addressable Display with Inherent Memory." AFIPS Conference
    Proceedings, Vol. 29, 1966.

BYERS, JOE L. Verbal Learning and Concept Learning. Review Series,
    Vol. 1, Michigan State University, 1968.

KOPSTEIN, FELIX F.; SEIDEL, R.J. "Computer-Administered Instruction
    Versus Traditionally Administered Instruction." Economics. George
    Washington University, June 1967.

REPORT OF THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE. Computers in
    Higher Education. February 1967.

SILBERMAN, H.F.; FILEP, R.T. "Information Systems Applications in
    Education." Annual Review of Information Science and Technology,
    Vol. 3, Encyclopedia Britannica, 1968.

Time-Sharing System Scorecard. Computer Research Corporation, Fall 1968.

VINSONHALER, JOHN F. Technical Manual: Basic Indexing and Retrieval
    System. Michigan State University, January 1968.